I want to explore what kinetic energy means. In this case, let's take two objects with about the same kinetic energy. A 94 lb (42.6 kg) cheetah running at 14 m/s (well within it's capability) and a rather powerful 23 gram bullet going at 602 m/s. What would happen if the cheetah runs straight into a 180 lb man? What would happen if the bullet hits a 180 lb man wearing a bullet proof vest? Let's assume the bullet doesn't exit, so all energy is transferred into the armor. What happens to the energy of the objects as they strike their targets?

Answer:

The kinetic energy of an object is the energy which it possesses due to its motion. In classical mechanics, the kinetic energy of a non-rotating object of mass m traveling at a speed v is ½ mv^2

$$E_k = \frac{1}{2}\, mv^2$$

To solve these problems you need to use momentum conservation law, which states that in a closed system (one that does not exchange any matter with the outside and is not acted on by outside forces) the total momentum is constant.

The momentum of a moving object is:

$$p = m * v$$

where

p is momentum,

m is the mass of the object,

v is the velocity of the object.

If you have more than one object at your system, then the total momentum is the vector sum of the momentums of each object.

To solve these problems we assume that the system is isolated.

Now, for given problems:

1)

A cheetah with

$$m_1 = 94lb = 42.6kg$$

is running with

$$v_1 = 14\frac{m}{s}$$

at a man with

$$m_2 = 180lb = 81{,}6kg$$

who is standing still

$$v_2 = 0$$

Before the collision (of the cheetah with the man) the momentum of the cheetah-man system was:

$$p = p_1 + p_2 = m_1 * v_1 + m_2 * v_2 = 42.6 * 14 + 81.6 * 0 = 596.4\ kg * m/s$$

(direction same as v_1)

After the collision, we assume that the cheetah and the man has "stuck together" and move like one single item.

As we said, after the collision the momentum of the system remains the same. So, the final momentum will be:

$$p = (m_1 + m_2) * u = 596.4\ kg * m/s$$

(u is the velocity of the "cheetah-man" item, because as we said now the cheetah and the man moves like one thing)

$$(m_1 + m_2) * u = 596.4\ kg * m/s$$

from there we easily find the final velocity:

$$u = 4.8\frac{m}{s}$$

Now, if you compare the new kinetic energy of the cheetah-man item

$$\left[\left(\frac{1}{2}\right) * (m_1 + m_2) * u\right]$$

and the separated kinetic energy of the cheetah before the collision

$$[(1/2) * m_1 * v_1]$$

you will see that a part of the kinetic energy is lost. This part of energy was transformed into heat.

Similarly of the second problem:

2)

At first the momentum of the system bullet-man is:

$$p = p_1 + p_2 = m_1 * v_1 + m_2 * v_2 = 0.023 * 602 + 81.6 * 0 = 13.846 kg * m/s$$

After the collision of the bullet with the man, the bullet and the man (temporarily) move together with the same velocity. The momentum of the system is maintained:

$$p = (m_1 + m_2) * u = 13.846 kg * m/s$$

so

$$u = \frac{13.846}{81.623} = 0.17\ m/s$$

Again, the system had more kinetic energy before the collision. After the collision a porton of the kinetic energy was transformed to heat.

References:

1) http://en.wikipedia.org/wiki/Kinetic_energy
2) http://en.wikipedia.org/wiki/Momentum#Conservation